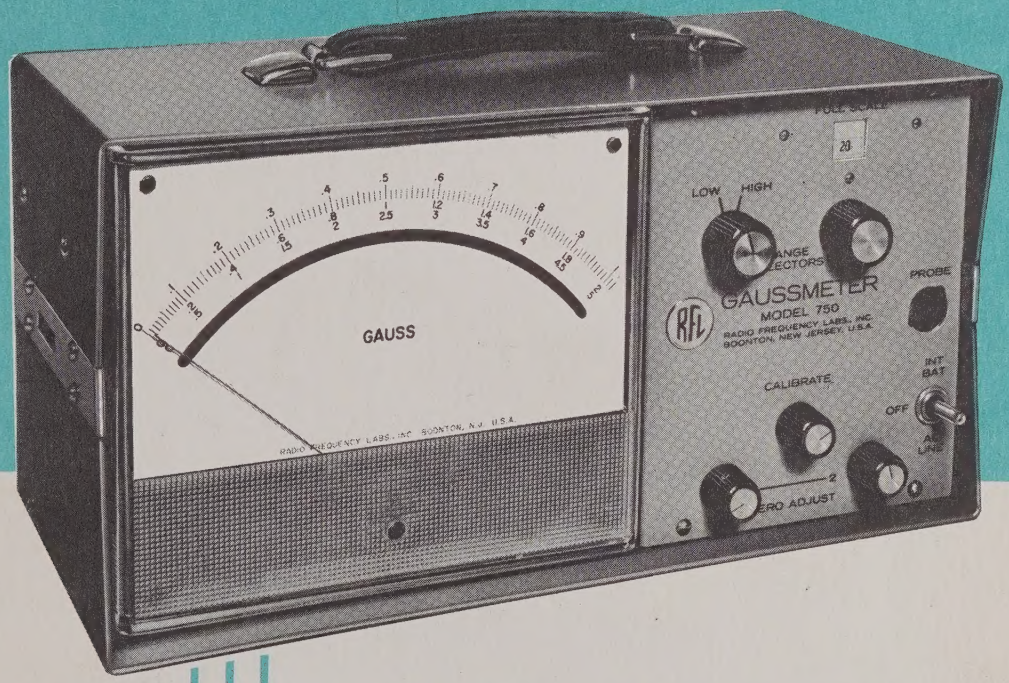
Manual of Instructions



Model 750 Gaussmeter

Radio Frequency Labs., Inc.

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Book No. MA-23200

MANUAL OF INSTRUCTIONS

Model 750 Gaussmeter

Radio Frequency Labs., Inc.

Figure 1. Front View of Model 750 Gaussmeter.

GENERAL DESCRIPTION

PURPOSE

The Model 750 Gaussmeter will measure magnetic fields from 0.01 to approximately 50,000 gausses.

The equipment operates on the Hall effect principle, enabling a sensing element of small physical size to be used for measuring flux densities. The probe element is indium arsenide, selected for best linearity and temperature stability. The use of transistors reduces equipment warm-up time to a minimum, and permits economical battery operation for portable or field use in addition to AC line operation.

The Model 750 provides a rapid means of checking magnetic instruments at any stage of their assembly. It is a complete instrument for making direct measurements of gap flux density in transverse or axial fields, and analyzing location, homogeneity and intensity of stray fields. It permits both quantitative and qualitative checking of design formula predictions.

DESCRIPTION

The Model 750, with the exception of its operating accessories (probe, reference magnet and zero gauss chamber), is completely self-contained in a metal case measuring 13½ inches wide 7 inches high by 6½ inches deep. The built-in power supply operates from a 115/230 volt, 50/60 Hz source. Receptacles are also built in to accomodate a set of batteries (not furnished) when operation as a portable field unit is desired.

When mounted on the adjustable cradle base assembly, the Model 750 may be tilted and locked in the most desirable position for easy operation. The conveniently located carrying handle on the top of the case makes the Model 750 easily transportable. (See Figure 2).

Figure 2. Model 750 Gaussmeter, Mounted on Accessary Cradle Base.

The extra large taut-band suspension meter on the front panel is equipped with a knife edge pointer and mirror scale for parallax correction. The meter is a core magnet type producing practically no stray fields to affect measurements made close to it. The meter mechanism provides better than 0.2 scale division repeatability, and its extra long scale with linear divisions allows for better than .001 gauss resolution of reading on the lowest scale.

All controls required for normal operation are located on the front panel adjacent to the meter, Figure 1. The RANGE SELECTOR switches provide for the selection of 24 fullscale ranges divided into two groups: a LOW of 12 ranges from 0.01 to 1000 gausses and a HIGH of 12 ranges from 10 to 50,000 gausses. The overlapping of portions of these ranges facilitates smooth continuity of operation. The ZERO ADJUST controls, marked 1 (coarse) and 2 (fine), are used to adjust the Model 750 to minimum meter reading with the probe inserted in the Zero Gauss chamber. The CALIBRATE control serves as the means by which full scale setting of the meter pointer is accomplished when the probe is inserted in a Reference Magnet.

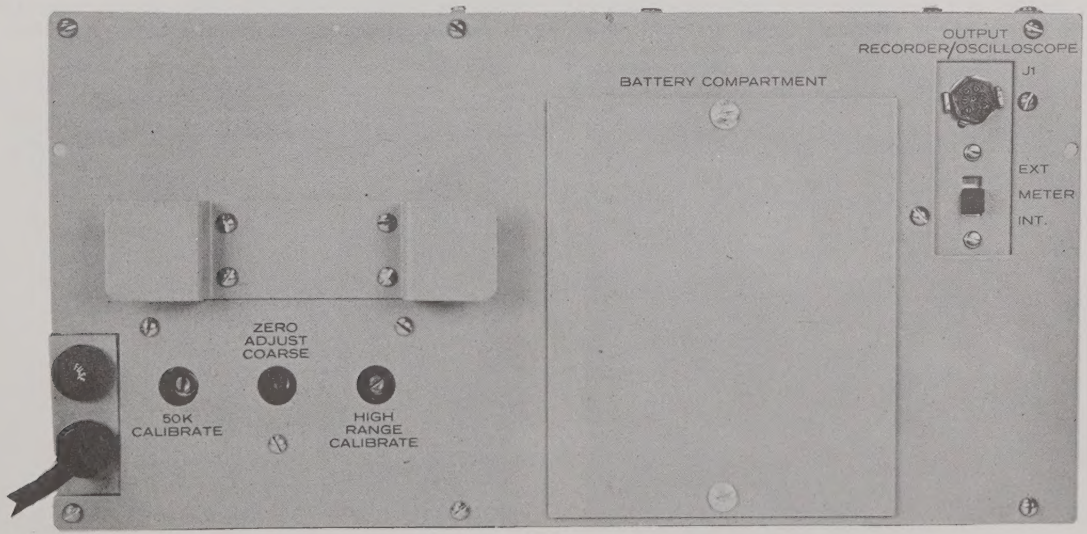


Figure 3. Model 750 Gaussmeter - Rear Panel.

On the rear of the Model 750 case (see Figure 3) is located the OUTPUT connector for the attachment of an external recorder, oscilloscope or meter. Also on the rear panel are supplementary controls for adjustment (as may be required) of full scale settings of the HIGH range and the 50K gauss range, and for extra-coarse zero adjustment when a new or different probe is used.

Table 1.

Limits of Error
in the Calibration of a ±3/4% Reference Magnet

Error	Description
±0.25%	Bureau of Standards accuracy of calibration of search coil.
±0.05%	Bureau of Standards accuracy of measurement of mutual inductor.
±0.10%	RFL accuracy of measurement of DC current.
±0.20%	RFL fluxmeter transfer reading error.
±0.15%	Non-uniformity of field in gap.
±0.75%	Maximum error.

PROBE REFERENCE MAGNETS

Stable, accurate permanent reference magnets are the heart of any magnetic flux measuring system which employs the Hall effect. Semi-conductor elements have not yet been discovered that are completely linear in response. Due to this non linearity, to yield a system accuracy within ±3% a properly designed and calibrated reference magnet is a necessity. RFL reference magnets are coaxial in form to eliminate stray fields in the area of measurement and to prevent magnetic change in the reference when contacting other strong magnets. The pole faces are accurately machined of special alloys to provide a uniform flux distribution. All reference magnets are stabilized and adjusted to full-scale values using mutual inductors and search coils having National Bureau of Standards certificates. Table 1 shows the approximate errors involved in the standardization of a ±3/4% reference magnet.

The 1000-gauss HB-9272 (±0.75%) reference magnet is basically required for all flat probes and the 500-gauss HB-11279 (±1.5%) reference magnet must be used with all axial probes. In the latter case, there is a type for each probe diameter. In addition to the two basic values, reference magnets having values from 5 to 20,000 gausses can be supplied. Some of these are listed below. Specify field desired.

PART NO.	VALUE	GAP
HB-9272	200 or 500 gausses (±1.5%)	.062"
HB-9272	1K, 2K or 5K gausses (±0.75%)	.062"
HB-9657	10,000 gausses (±0.75%)	.040"
HB-16582	20,000 gausses (±0.75%)	.040"
HB-16578	10,000 gausses (±0.75%)	.062"
HB-16572	100, 200 or 500 gausses (±1.0%)	.156"
HB-16574	1000 or 2000 gausses (±0.75%)	.156"
HB-16576	500 gausses (±0.75%)	.156"
HB-16655	5, 10 or 20 gausses (±1.5%)	.343"
HB-16570	50, 100 or 200 gausses (±1.0%)	.343"
HB-16660	500, 1000 or 2000 gausses (±3/4%)	.343"
*HB-11279	500 gausses (±1.5%)	5/16" dia.
HB-21990	1000 or 2000 gausses (±1.5%)	5/16" dia.

*The HB-11279 500 gauss reference magnet is supplied with sleeves of .200, 5/32, and .100 diameter gap depending on probe diameter supplied.

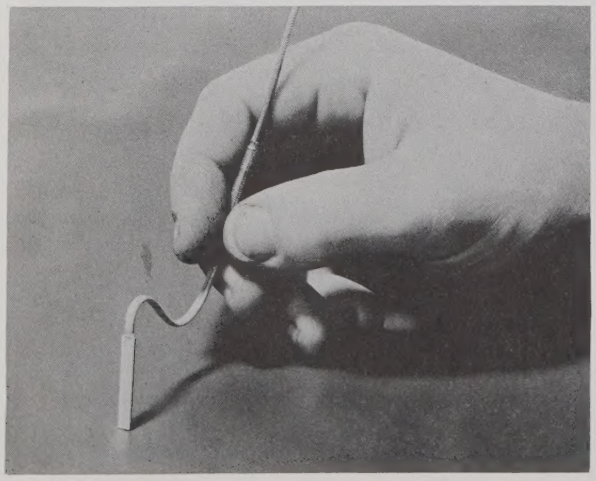


Figure 4
Typical Flat Probe Showing Flexibility.

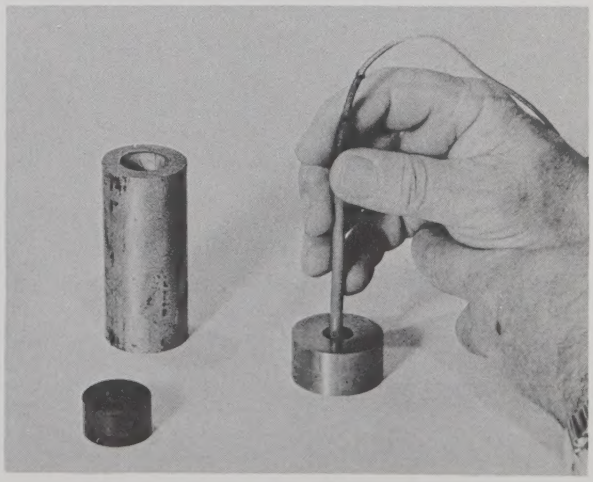


Figure 5
Typical Axial Probe.

PROBES

Both the flat and axial probe types are constructed of non-metallic glass reinforced epoxy and are equipped with light, flexible cables for probing narrow apertures with a maximum sense of "feel" for the delicate element embedded in the tip. A typical flat probe for measuring transverse fields and an axial probe for magnetic fields parallel to its long axis are shown in Figures 4 and 5 Standard cables are 5 ft. long with extension cables available up to 50 ft. in length. Presently available, standard InAs probes are:

HB-13460 Flat .025" thick x 13/64" wide x 1" long
HB-13475 Flat .020" thick x 1/8" wide x 9/32" long
HB-13477 Tangential .040" thick x 13/64" wide x 1" long
HB-15950 Flat 1 mm (.039") thick x 13/64" x 1" long
HB-21800 Flat .112" thick x 0.2" wide x 1" long
HB-13470 Axial 5/16" diam. w/5 ft. cable
HB-13472 Axial 0.20" diam. w/5 ft. cable
HB-11261 Axial 5/32" diam. w/5 ft. cable
HB-13482 Axial 0.10" diam. w/5 ft. cable

Flat probes should be handled carefully and stored in their plastic box when not in use. The InAs element is extremely brittle and should never be subjected to squeezing or bending. Flat probes are supplied with a non-metallic tubular sheath to protect the probe tips. The sheath may be retraded to expose whatever length of probe is desired, or may be removed completely. (See Figure 6).

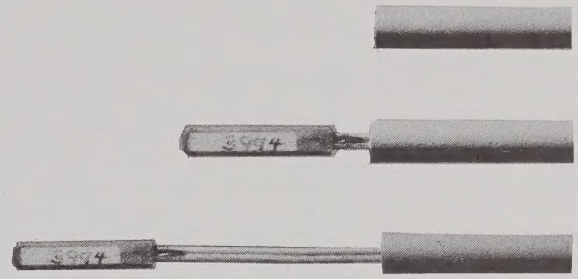


Figure 6. Flat probe and protective sheath.

ELECTRICAL FEATURES

Each probe is supplied with a test data sheet which contains electrical and temperature stability values measured for that probe, plus calibration data for each range as measured using laboratory standard reference magnet fields for each full-scale range. Since sensitivity of InAs decreases above 10,000 gausses, downscale data are particularly necessary on the 50,000-gauss range. This permits use of the 50,000-gauss range in making measurements above 20,000 gausses.

Table 2.
Technical Data Summary

Accuracy.

±(1% plus reference magnet accuracy) full-scale. Downscale linearity better than 0.5% of full-scale.
Overall accuracy (using 1000-gauss reference magnet) ± 3% of full-scale range value to 10,000 gauss, On the 20,000 and 50,000-gauss ranges, probe linearity data must be used to obtain specified accuracy. All calibration data traceable to the National Bureau of Standards through reference standards maintained at RFL and periodically checked by NBS.
Probe data is supplied to 25000 gausses.

Measurement Ranges. Gauss full-scale

Low: 0-0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200 and 1000.

High: 0-10, 20, 50, 100, 200, 500, 1000, 2000, 5000, 10,000, 20;000 and 50,000.

Residual noise.

Less than 10 milligauss.

Balance Controls.

Two front panel controls for normal operation. One coarse control mounted on rear of unit to facilitate use of a wide range of Hall elements.

Resolution.

1/10th of scale division. (zero to full-scale = 100 divisions).
Repeatability of measurement is within 0.2 scale division.

Frequency Range of Measurement.

Permanent magnet, DC and AC fields from 20 to 400 Hz for specified accuracy.
Usable indications from 1 to 20 Hz.
AC measurements are in terms of average flux density.

Accessory Output Connections.

Seven-pin, plug-in type receptacle for external recorder, oscilloscope or digital voltmeter. Will operate into either d'Arsonval or electronic type chopper stabilized recorders. Output is 1 MA into 1500 ohms.

Power Line Requirements.

115 or 230-volt, 50/60 Hz.
Power drain 5 watts at 60 Hz.
(May also be operated from batteries, approx. life 100 hours).

THEORY OF OPERATION

THE HALL EFFECT

When electrons move in a conductor perpendicular to a magnetic field, they are deflected toward one side of the conductor (left or right depending on the direction of the magnetic field) in a direction normal to the direction of both the initial electron flow and the magnetic field. The force deflecting the electrons is directly proportional to the electron velocity (current) and the magnetic field intensity. This deflection process continues until sufficient charge has accumulated at the sides of the conductor to establish a transverse electric field which opposes further deflection of charge carriers. The transverse potential difference thus created is called the Hall voltage and the phenomena causing it, the Hall effect.

The magnitude of this potential in volts is given by the equation:

$$E = \frac{RIH}{t} ,$$

where I is the current in amperes, H is the magnetic field strength in gausses, t is the thickness of the sample in centimeters, and R is the Hall coefficient in volt-cm/ampere gauss.

Under the conditions shown in Figure 7, the terminal B will be negative with respect to terminal A for metals and semiconductors in which the current is carried by electrons. Reversing the field reverses the output polarity. As shown by the equation above, the width of the strip is not a factor of the output as long as it is large compared to the thickness. The strip should be twice as long as it is wide or the output drops off. For thin strips the output is unaffected by the frequency of the field in the audio range. The Hall voltage is maximum when the plane of the element is perpendicular to the magnetic field.

Practical materials for Hall elements are films and slabs of specially refined semiconductors. The sensitivity, temperature stability and linearity to fields can be varied through wide ranges by selection of materials. One characteristic can usually be improved at the expense of the other characteristics. Hall elements made of InAs, InSb and other similar III-V compounds require a loading resistor across the Hall contacts for best linearity in strong fields above 2000 gausses. This resistor is determined experimentally for each element.

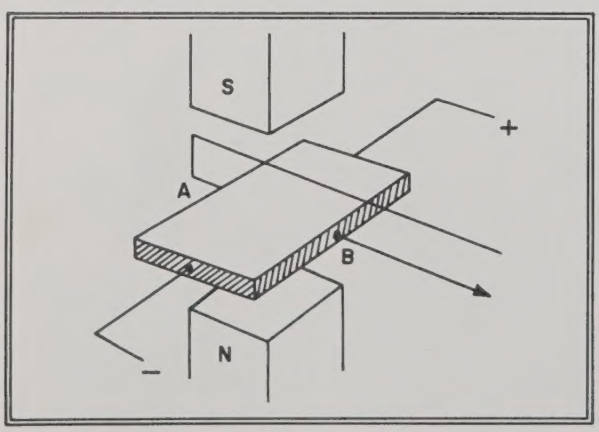


Figure 7. Schematic Circuit Arrangement for the Measurement of the Hall Coefficient.

The flat and axial probes for use with the Model 750 Gaussmeter are manufactured using a very thin piece of InAs which is selected for use in the temperature range of 32°F to 165°F.

CIRCUIT ARRANGEMENT

The block diagram of Figure 8 shows the arrangement of circuits in the equipment. The 3000-Hz oscillator is designed to supply a constant current to the current terminals of the probe element. The potential leads are brought from the probe to a 3000-Hz filter with a 1000-Hz bandwidth. A balancing network is provided to inject a small voltage into the pickup loop to balance out the residual resistive unbalance in the probe. The ZERO ADJUST control on the front panel adjusts the phase and magnitude of this injected voltage. The purpose of the filter is to remove harmonic voltage from the signal as generated in the 3000-Hz oscillator and step the voltage up by a factor of ten. A 12-step attenuator permits measurements from 0.01 gauss to 50,000 gausses. The signal is amplified and rectified to operate the meter or external recorder. The final stage uses current feedback to improve the linearity of the meter rectifiers and is powerful enough to drive many DC recorders directly without further amplification. The over-all sensitivity is varied with a front panel CALIBRATE control. The regulated power supply provides the necessary DC power voltage. Semiconductor devices are used for rectification and amplification in all circuits.

TEMPERATURE EFFECT

As the semiconductor material has a temperature coefficient of resistance about the same as copper, the resistive zero balance of the probe is sensitive to temperature. The zero shift is, of course, greatest on the sensitive 0.1 gauss range. When the ambient temperature of the probe is changed, the zero should be checked and reset. The zero shift is about one gauss for a 10°C change of temperature on the probe.

The Hall coefficient of the InAs material also changes with ambient temperature. The sensitivity of the probe may change approximately 0.1%/°C when submitted to ambient variations after calibrating with a reference magnet. The reference magnets change approximately 0.02%/°C; the magnet will return to its original calibration when normal temperature is restored. An ambient temperature above 180°F may permanently change the calibration of the magnet. A variation in ambient temperature also changes the rectification efficiency of the diodes in the meter circuit. These changes are normally eliminated by calibration at the temperature of use.

PROBE SENSITIVITY

The Hall elements normally used with the Model 750, are matched to filter input impedance for best linearity, and will supply 2.5 mV output when subjected to a 1000-gauss field and driven with 50mA ±20%. The average value of K is 50 x 10^{-6} in the formula: V_H = KHI, where V is the Hall voltage in volts, H is the magnetic field in gausses, I is the current in amperes and K is the Hall constant.

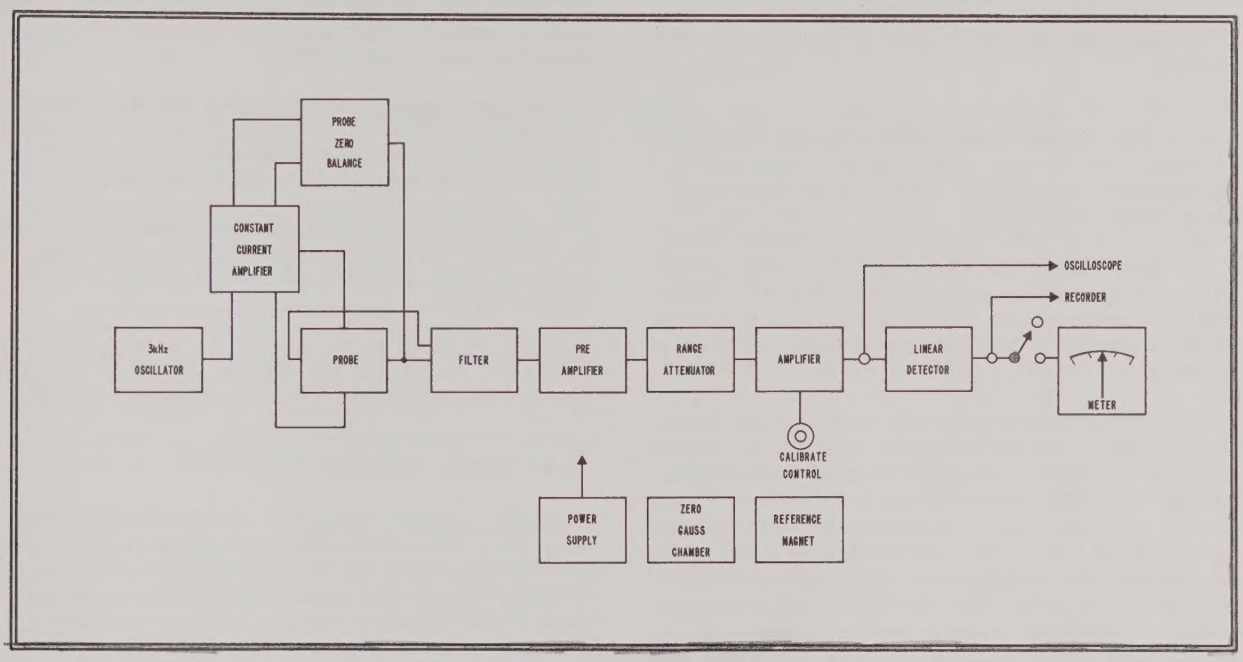


Figure 8. Block Diagram of 750 Gaussmeter.

OPERATION

OPERATION (STEP-BY-STEP)

1. Operate RANGE SELECTOR switch to LOW POSITION, and set FULL SCALE indicator to 1000 gausses.

2. For AC operation, plug line cord into power source and operate toggle switch to AC LINE. For operation from internal battery supply, stow line cord on brackets provided on rear of case and operate toggle switch to INT BAT.

3. Insert probe cable plug into receptacle on front panel. (When making measurements on lower ranges, rest a suitable weight on the probe cable to prevent undue movement of the cable immediately adjacent to the plug.)

4. Carefully insert probe into ZERO GAUSS CHAMBER, then slowly rotate ZERO ADJUST #1 control until minimum meter reading is obtained. Rotate FULL SCALE indicator knob through successively lower ranges, repeating the zero adjusting operation for each step until the lowest meter reading for the lowest range is obtained. Continue the above procedure using ZERO ADJUST #2 control. Final adjustment of controls #1 and #2 is achieved when a reading of less than 10 milligausses on the 0.1 gauss range is observed.

5. Operate RANGE SELECTOR switch to HIGH or LOW position depending on value of field strength to be measured. Set FULL SCALE indicator to value marked on reference magnet.

6. Remove probe from ZERO GAUSS CHAMBER and carefully insert it into the center of the reference magnet, positioning the probe so as to obtain maximum meter reading. With CALIBRATE control adjust reading to exact full scale value marked on reference magnet. (When using flat probe, turn it over 180° and calibrate in position producing greatest reading).

7. Remove probe from reference magnet and place it in field to be measured. Position probe so that lines of force are perpendicular to probe sensing element. Operate FULL SCALE indicator control to range providing highest on-scale meter reading.

EXTERNAL ACCESSORIES

A seven-pin receptacle, with locking plug, is provided on the rear panel of the unit for connection by suitable cable to an external recorder, oscilloscope, or digital voltmeter. The Model 750 Gaussmeter will accommodate either d'Arsonval or electronic chopper type recorders. The output for external accessories is 1 ma into 1500 ohms.

When connecting an external accessory, care should be taken to properly wire the accessory cable and plug, as follows:

Recorder or Meter (d'Arsonval type approximately 1500 ohms) - Connect the positive side of the recorder (or meter) to terminal "B" of the plug and the other side to terminals "D" and "E". The METER switch should be in the EXT position.

Recorder (chopper type) or Meter (digital) - Connect the positive side of the recorder (or meter) to terminal "B" of the plug and the other side to terminal "D". The METER switch should be in the INT position.

Oscilloscope - Connect one side of the oscilloscope to terminal "A" of the plug and the other side to terminal "E". The METER switch should be in the EXT position.

When returning to the use of the built-in meter of the Model 750, place the METER switch in the INT position and remove the external accessory cable plug.

REAR PANEL CONTROLS

ZERO ADJUST COARSE - Initial balance adjustment using this control may be required when original probe shipped with Model 750 is replaced, or when a different Hall element probe is used. Adjustment using this control should be made prior to following the procedure under Step 4 above for ZERO ADJUST #1.

HIGH RANGE CALIBRATE - This control serves to compensate for the resistive unbalance between common values on the LOW and HIGH ranges. When setting up to perform a span of continuous measurements, for example from 1 gauss to 10K gausses, the full scale adjustment (Step 6) for the LOW ranges is obtained using the CALIBRATE control on the front panel. To obtain full scale adjustments for the same value on the HIGH range, use the HIGH RANGE CALIBRATE control on the rear panel. This procedure will eliminate the introduction of an error of up to 3% when shifting back and forth between the LOW and HIGH ranges.

50K CALIBRATE - The measurement of magnetic fields in the order of 20K to 50K requires the use of a special probe and a high value reference magnet. Zero adjustment is made as outlined in Step 4 above, then the calibration is made using the 50K CALIBRATE control and the data supplied with probe.

USE OF PROBE TEST DATA

The Hall effect of InAs is not linear when subjected to fields greater than 15000 gausses. With careful measurement and loading, elements can be selected to provide all points on their response curves within three meter divisions from 0.1 to 10,000 gausses when calibrated in a single reference magnet. Above 10K gausses the response falls off fairly rapidly, and calibration data or correction factors are necessary. Using the reference magnet selected, direct reading

accuracy on all full scale ranges from 0.1 to 10K gausses will be within ±3%. For accuracy approaching ±1%, the meter reading may be corrected with the calibration data.

Where different types of probes are used, check the Test Data Sheet for each to determine the value of reference magnet for calibration.

TEMPERATURE AND STRAIN

On the low gauss ranges, temperature becomes an important factor. Temperature change is given in the probe Test Data Sheet. Also, any mechanical strain applied to the element is readily indicated. Both conditions can be observed by breathing on the probe and lightly touching its end after zero balancing. Moving the cable excessively, especially where it enters the plug body, can cause erratic readings on the lowest ranges, hence the reason for resting a weight on the cable to anchor it. Short term instability or long term drift not caused by a changing magnetic field are almost always traceable to element temperature changes or mechanical displacement.

FIELD POLARITY

Polarity of magnetic fields up to 100 plus gausses can be determined. This is done by inserting the probe in the 0-gauss chamber and by adjusting the ZERO ADJUST #1 CONTROL, move the meter pointer to the center scale position on the range desired for the sensitivity required. It will then read right or left with field direction.

MEASURING AC FIELDS

For sine wave fields above 50 Hz, multiply the meter reading by the correction factor obtained from the curve shown in Figure 9. When the probe is placed in an AC magnetic field the meter reads the average value of the field. If it is desired to observe the wave shape, connect an external oscilloscope by means of the receptacle provided on the rear panel of the unit. The display on the oscilloscope will show the carrier and its envelope. The output may be defined as double side band with suppressed carrier. (Refer to paragraph on EXTERNAL ACCESSORIES for connection instructions).

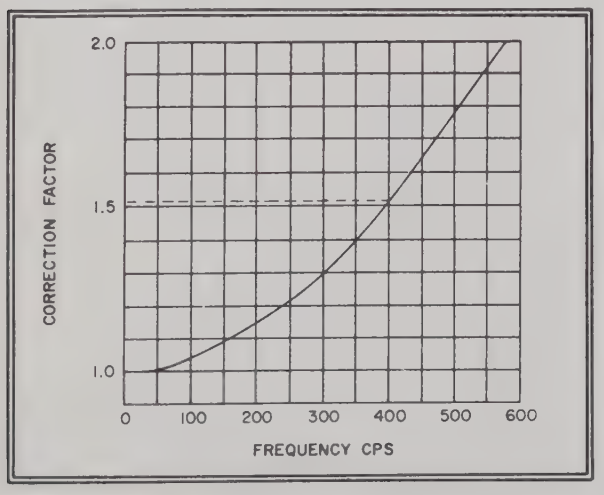


Figure 9. Frequency Response Correction.

SUBSTITUTE REFERENCE MAGNETS

Operation of the Model 750 Gaussmeter requires a reference magnet for any and all measurements and should include the 0-Gauss Chamber when the possibility of ambient or stray fields are strong enough to affect zeroing operations.

All RFL flat probes for Model 750 Gaussmeter use are selected, matched, resistive loaded and calibrated in a laboratory standard 1000-gauss field. The calibrated values listed on the Probe Data Sheets supplied with each flat probe are based on this 1000-gauss reference and set forth the full range performance of the specific probe when adjusted to zero error at 1000 gausses (±0.5%).

For maximum accuracy, the reference magnet value must be a full scale value available on both the LOW range and HIGH range, since the resistive unbalance between HIGH and LOW settings can be as high as 3%.

Although not advisable, should the user of a Model 750 Gaussmeter desire to make flat probe measurements without a 1000-gauss reference magnet of at least 3/4% accuracy the following advice is pertinent:

1. Determine the exact value of the substitute reference magnet because, if it is less than 10 gausses or more than 2000 gausses, it cannot be used accurately for both HIGH and LOW ranges. If the probe is calibrated and the RANGE SELECTOR is then shifted (to either HIGH or LOW) an added error up to 3% can be introduced depending upon the resistive unbalance between the LOW and HIGH ranges.

2. In calibrating with the substitute magnet, the Gaussmeter must be adjusted to read the actual value of the magnet corrected by the full scale factor shown for the magnet value on the Probe Data Sheet. If the substitute reference magnet is not a full scale value, the ½% meter tracking error should be considered.

3. Since it is quite likely that the substitute reference magnet has a larger limit of error than than the RFL ±0.5% standard magnet used to compile the Probe Data Sheet, its greater tolerance should be considered in calculating the over-all accuracy.

MAINTENANCE

CALIBRATION PROCEDURE

To expose calibration adjustments and test points, remove case halves by first removing the top four (4) screws on each end of the cabinet. Separate case halves by gently lifting top section by means of handle. Then remove chassis from bottom section of case. See Figure 10 for location of adjustments and test points.

Oscillator (Reference etched circuit board HC-23207) - As shown in the Schematic Diagram Figure 14, the oscillator coil L2 has a multi-tap secondary for matching into the current terminals of the Hall element. These taps are wired to the PROBE receptacle on the front panel and all that is required is to plug the probe in for immediate operation. The adjustment of the oscillator requires the setting of the OSC. GAIN control R15 on the oscillator board assembly for a specified output or drive voltage across terminals 1 and 2 of J2, with a 2 ohm load resistor across these terminals. For the usual RFL InAs probe this voltage is in the order of 0.1 volt. The nominal resistance of InAs probes is 2 ohms between the current leads and 1 ohm between the Hall voltage leads. The 3000 Hz current input to the element is, therefore, approximately 0.050 amperes. Figure 11 shows the location of the component parts on the Oscillator and Filter etched board HC-23207.

Hall Probe Elements - Load resistors, when required for best probe linearity in high field measurements, are determined for each Hall probe and are mounted in the connector plug. The procedure for determining the load resistor Ra for a Hall element at the factory is as follows:

(1) Set the RANGE SELECTOR to 1000 gausses on the HIGH range. Using a 1000 gauss reference magnet, adjust the CALIBRATE control until the meter reads full scale.
(2) Connect a variable resistance decade to pins 5 and 7 of J2 and using corresponding reference magnets adjust the decade so that full scale readings on the 2000, 5000, and 10000 gauss ranges are within 2% of full scale mark.
(3) Alternately repeat (1) and (2) above until specified settings are obtained.
(4) If it is not possible to obtain the specified settings in (2), select the next higher probe matching impedance by changing the connections of the decade to pins 6 and 7 (10 ohms) or 4 and 7 (20 ohms) and repeating the above procedures.

It will be noted that with the probe unloaded (decade box disconnected), the readings at 5000 and 10,000 gausses will be high by about 4% to 8% when the instrument has been initially set at 1000 gausses.

A load resistor of the value so obtained by the above procedures is then soldered in place of the variable resistance decade. For most RFL InAs probes, this loading resistor Ra varies between 3.3 and 15 ohms when the probe is driven from the 5 ohm tap of the oscillator coil L3. Under certain conditions, resistor Rb may be used in conjunction with, or in place of, Ra. Refer to Schematic Diagram and follow above resistor selection procedure.

Calibration records on each range are provided for the probe and gaussmeter supplied on each order. These data permit measurements to a greater accuracy than the direct reading accuracy. Probes may be interchanged between units without loss of direct reading accuracy. For highest accuracy, the probe should be calibrated with the unit with which it is used.

The sensitivity of a probe may be checked by measuring AC voltage present between ground (green wire) on the attenuator and TP1 on the 2.5K resistor R71 with the probe in a 1000 gauss field and with the oscillator drive voltage across terminals 1 and 2 of J2 set at 0.1 volt. The signal output of the filter should then be between 0.04 and 0.09 volts.

Amplifier (Reference etched circuit board HC-23206) - The adjustment of the amplifier section shown in Figure 12 consists of setting the input resistance of the amplifier to 2500 ohms, and the setting of 3 gain controls. The input resistance is adjusted by means of R55. Connect a high impedance vacuum tube voltmeter between TP1 and ground. With the probe plugged in and the RANGE SELECTOR set to the 0.1 gauss range, adjust ZERO ADJUST #1 control until a voltmeter reading of .0004 volt is obtained. Move the voltmeter lead from TP1 to TP2 and adjust R55 for a voltmeter reading of .0002 volt. Repeat this operation until the voltage at TP2 is ½ that at TP1. Since the multiplier resistor R71 is 2500 ohms ±1%, the above procedure sets the input to the amplifier to 2500 ohms as required to obtain the correct attenuation on the other gauss ranges.

The overall sensitivity of the amplifier is adjusted by means of potentiometers R27, R41 and CALIBRATE control R3. To obtain the proper sensitivity (CALIBRATE control in full counter-clockwise position) connect the voltmeter between TP1 and ground (green wire on attenuator) and adjust ZERO ADJUST control to obtain full scale on the 0.1 gauss range. Then with R27 and R41 set in their mechanical center positions, adjust R27 and R41 equally to read .00011 volts on the voltmeter. Repeat this procedure for the ZERO ADJUST control and R27 and R41 until both conditions are satisfied without further adjustment.

The 10:1 sensitivity ratio between the LOW and HIGH scales of the RANGE SELECTOR S3 is obtained by first adjusting the 1000 gauss full scale reading on the LOW range using the CALIBRATE control on the front panel. Then operate the RANGE SELECTOR to the HIGH range position and obtain full scale adjustment on this range by using the HIGH RANGE CALIBRATE control R84 on the rear panel. This adjustment will vary for different probes as the setting of R84 is not entirely independent of the setting of the front panel CALIBRATE control R3.

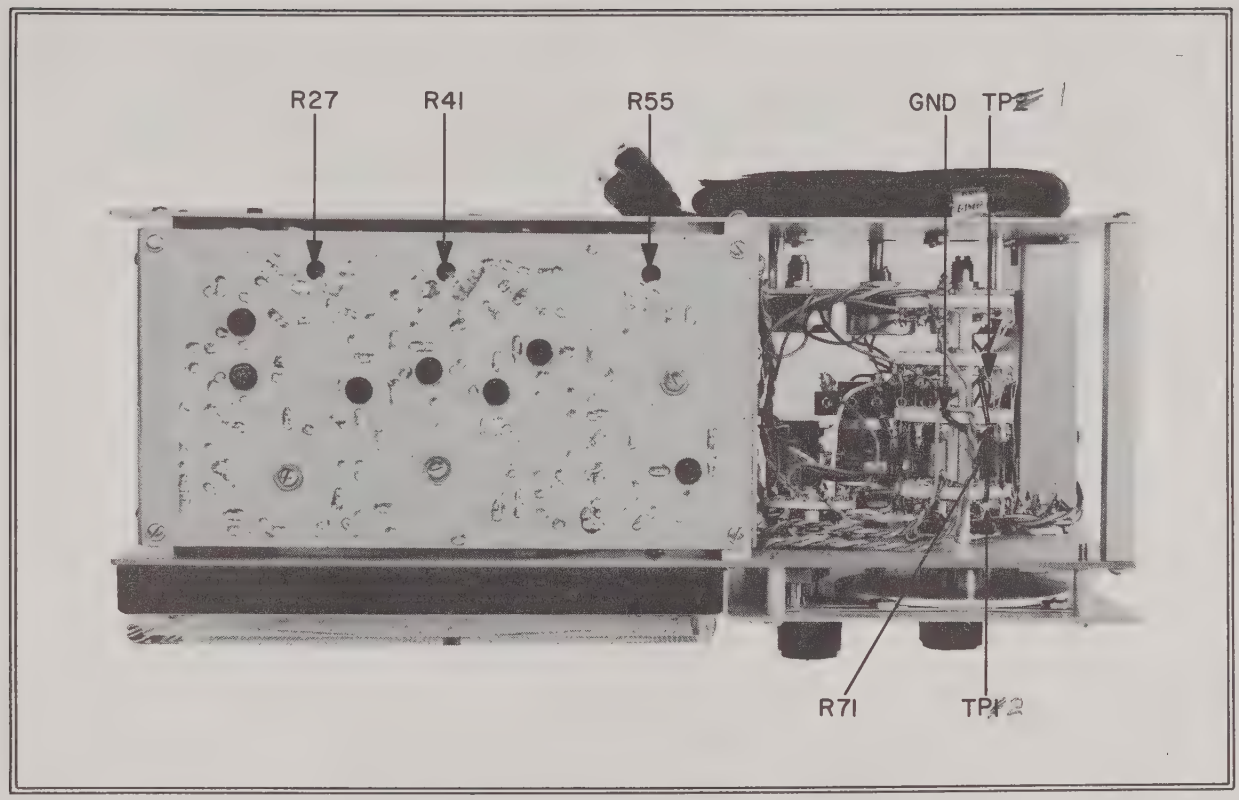


Figure 10. Model 750 Gaussmeter - Case Removed.

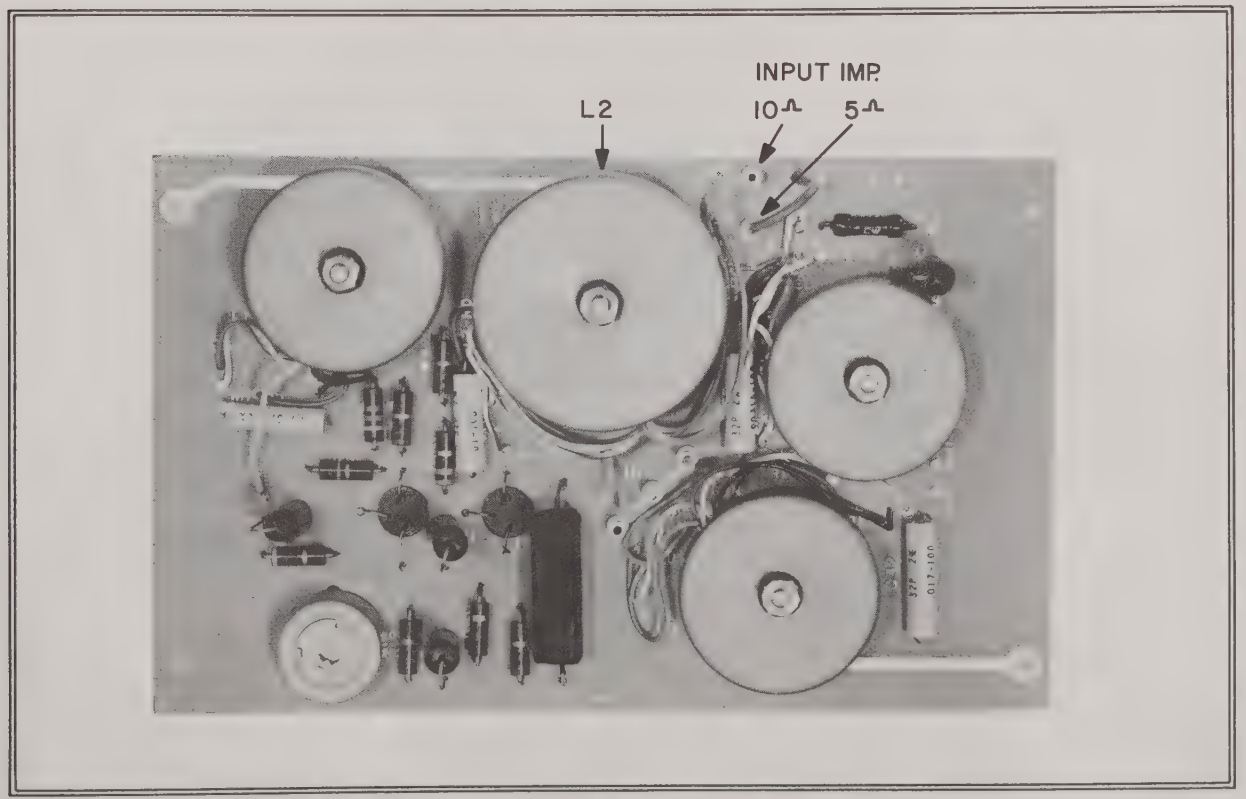


Figure 11. Oscillator and Filter Assemble (Etched Circuit Board HC-23207).

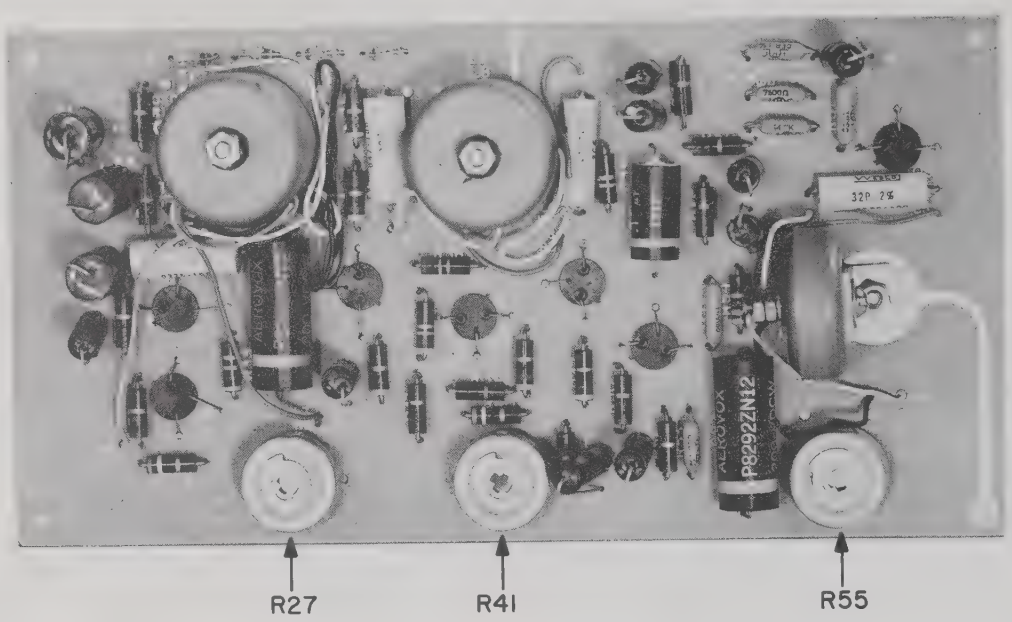


Figure 12. Amplifier Assembly (Etched Circuit Board HC-23206).

Figure 13. Power Supply Assembly (Etched Circuit Board HC-23208).

Attenuator - A complete check of the attenuator ranges requires reference magnets for the full scale reading on each range. The attenuator resistance values are set so that after full scale adjustment is obtained with any reference magnet, the other full scale values will fall within ±3%. For maintenance purposes a partial check on the attenuator and probe would be to set the CALIBRATE control for full scale on the 1000 gauss HIGH range using the 1000 gauss reference magnet. Then measure this field on the 2000 and 5000 gauss ranges. No adjustment is provided on the attenuator, and a failure in the attenuator will normally require that the equipment be returned to the factory for repair. If a second probe is available, it may be used to check the condition of the first probe.

TROUBLE SHOOTING

Follow trouble shooting steps listed in Table 5 and make measurements as required to confirm voltage values shown in Tables 3 and 4.

Component parts and subassemblies may be identified and located by reference to Figures 10, 11, 12 & 13 and the Schematic Diagram Figure 14.

Replaceable Parts List Table is provided for your convenience in ordering replacement parts when neccessary.

Table 3.
AC Voltage Chart

AC LINE SUPPLY

NOTE
All measurements made with a high impedance vacuum tube voltmeter.

POINTS OF TEST	AC VOLTAGE
OSCILLATOR	
Q1 - B to GND	.1
Q1 - C to GND	4.3
Q2 - B to GND	.045
Q2 - C to GND	4.1
AMPLIFIER - 1000-gauss low range. (Range switch, 1K gauss).	1000-gauss field thru probe.
Q3 - C to GND	2.4
Q4 - C to GND	.0215
Q5 - C to GND	.066
Q6 - C to GND	.0024
Q7 - C to GND	.0042
Q8 - C to GND	.00022
Q9 - B to GND	.074
Q9 - C to GND	.9
Q9 - E to GND	.066

Table 4.
DC Voltage Chart

AC LINE SUPPLY

POINTS OF TEST	DC VOLTAGE
POWER SUPPLY - 115 V AC	
OSCILLATOR	
4-9- to GND	18.5
Q1 - C to GND	8.23
Q1 - B to GND	1.35
Q1 - E to GND	1.28
Q2 - C to GND	16.5
Q2 - B to GND	6.1
Q2 - E to GND	5.95
AMPLIFIER	
1-5- to GND	19.3
Q3 - E to GND	5.2
Q3 - B to GND	5.3
Q3 - C to GND	17.4
Q4 - E to GND	.15
Q4 - B to GND	.25
Q4 - C to GND	5.3
Q5 - E to GND	5.4
Q5 - B to GND	5.5
Q5 - C to GND	9.4
Q6 - E to GND	.1
Q6 - B to GND	.24
Q6 - C to GND	5.5
Q7 - E to GND	4.1
Q7 - B to GND	4.1
Q7 - C to GND	8.6
Q8 - E to GND	.65
Q8 - B to GND	.7
Q8 - C to GND	4.1
Q9 - E to GND	2.2
Q9 - B to GND	2.2
Q9 - C to GND	7.4

Table 5.
Trouble Shooting Chart

TROUBLE	POSSIBLE CAUSE	REMEDY
Operation on 115 volts AC power.	Blown fuse, faulty plug.	Check for shorts in the power supply and replace fuse. Measure DC output of power supply to be 18 volts ±10%.
ZERO ADJUST controls have little or no effect in obtaining lowest reading on any range.	Open potential leads in probe, open cable, or cracked element.	Check by shorting pins 5 and 7 of J-2 together and observing actions of controls. If no action, trouble shoot the amplifier. Replace faulty probe if controls operate the meter.
	Oscillator not functioning.	Check AC voltage between pins 1 and 3 of connector J-2 (probe removed). If no voltage, trouble shoot the oscillator circuit and power supply.
	Open current leads in probe.	Measure with ohmmeter and replace probe if defective. (Note: ohmmeter current must not exceed 150 mA).
No oscillator output voltage.	Defective component in oscillator section of etched circuit board Figure 11.	Trouble shoot oscillator circuit using Tables 3 and 4 for guides as to voltages. Trouble shoot power supply circuit. (See Figures 13 and 14).
Low voltage of approximately .025 volt on TP1 for 1000 gausses on normal probe.	Defective filter.	Remove filter connections and test with 50 ohms input impedance and 5000 ohms on output. The step-up ratio is approximately 10:1. Bandwidth about 1000 Hz. Center frequency of 3000 Hz. Replace filter if defective.
No amplifier output indicated by meter.	Defective component in amplifier or meter circuit.	Signal trace circuit by applying 3000 Hz signal between input terminal TP2 and ground, and use Tables 3 and 4 as voltage guides.

Table of Replaceable Parts

DIAGRAM SYMBOL	NAME OF PART AND DESCRIPTION	RFL PART NO.
BT1, BT2, BT3	BATTERY: mercury cell, 6.75 v	HA-23807
C1, C17, C27	CAPACITOR, metalized paper: plastic case, 0.5 mf, ±20%, 200 v	H-1007-211
C2, C24	CAPACITOR, metalized paper: plastic case, 0.1 mf, ±20%, 200 v	H-1007-64
C4, C5	CAPACITOR, electrolytic: 500 mf, 50 v	HA-13569
C6	CAPACITOR, polystyrene: .0068 mf, ±2%, 100 v (matched to HB-9286 Coil (L1))	H-5115-27
C7, C8, C9, C16, C18, C19, C20, C22, C25, C26, C29, C30, C31	CAPACITOR, electrolytic: 10 mf, -10% +250%	HA-13167
C10	CAPACITOR, polystyrene: .01 mf, ±2%, 100 v (matched to HB-23222 Coil (L2))	H-5115-200
C11	CAPACITOR, metalized paper: 3 mf, ±20%, 50 v	H-1080-289
C12, C13, C14	CAPACITOR, electrolytic: 25 mf, -10%, +250%, 25 v	HA-6632
C15	CAPACITOR, polystyrene: .0375 mf, ±2%, 100 v (matched to HB-11751 Coil (L7))	H-5115-62
C21	CAPACITOR, polystyrene: .0470 mf, ±2%, 100 v (matched to HB-11753 Coil (L8))	H-5115-67
C23	CAPACITOR, polystyrene: .0285 mf, ±2%, 100 v (matched to HB-11752 Coil (L6))	H-5115-56
C28	CAPACITOR, polystyrene: .0255 mf, ±2%, 100 v (matched to HB-23216 Coil (L5))	H-5115-54
C32	CAPACITOR, polystyrene: .017 mf, ±2%, 100 v (matched to HB-23218 Coil (L3))	H-5115-46
C33	CAPACITOR, polystyrene: .00315 mf, ±2%, 100 v (matched to HB-23217 Coil (L4))	H-5115-10
CR1, CR2	DIODE, silicon	HA-10271
CR3	DIODE, zener, silicon	HA-13569
CR4 to CR7	DIODE: 1N155	HA-13242
E1	KNOB: black, Range Selector	HA-23256
E2, E3	KNOB: black, Zero Adjust	HA-23412
E4	KNOB: black, Calibrate	HA-23413
E5	KNOB: black, High-Low Range Selector	HA-23414
F1	FUSE: ½ amp, 250 v, 3AG	HA-9348
J1	CONNECTOR, min. hex: 7-pin socket, w/locking clip	HA-23698
J2	SOCKET, tube: min. 7-pin.	HA-13258
L1	COIL, tuned: 0.4 hy, oscillator input (tuned with C6 to 3000 Hz)	HB-9286
L2	COIL, tuned: .28145 hy, oscillator output (tuned with C10 to 3000 Hz)	HB-23222

Table of Replaceable Parts

DIAGRAM SYMBOL	NAME OF PART AND DESCRIPTION	RFL PART NO.
L3	COIL, tuned: .2208 hy, input filter matching (tuned with C32 to 3000 Hz)	HB-23218
L4	COIL, tuned: .21106 hy, input filter matching (tuned with C33 to 3000 Hz)	HB-23217
L5	COIL, tuned: .111 hy, preamp, transformer (tuned with C28 to 3000 Hz)	HB-23216
L6	COIL, tuned: .111 hy, amplifier filter (tuned with C23 to 3000 Hz)	HB-11752
L7	COIL, tuned: .075 hy, amplifier filter (tuned with C15 to 3000 Hz)	HB-11751
L8	COIL, tuned: .0672 hy, amplifier filter (tuned with C21 to 3000 Hz)	HB-11753
M1	METER, indicating: 1 ma ±1% (FS), 1500 ohms ±5%	HC-23211
P1	CONNECTOR, min. hex: 7-pin plug, w/hood & clamp	HA-23699
Q1, Q3 to Q9	TRANSISTOR: 2N324	HA-9365
Q2	TRANSISTOR: 2N1925	HA-17179
R1, R2	RESISTOR, fixed comp: 680 ohms, ±10%, ½ w	H-1009-473
R3	RESISTOR, variable WW: tandem; 200 ohms front (panel), 1.5K rear, ±10%, linear taper, bushing 3/8-32 x 3/8" long, shaft 1/4" round x 1-1/4" long from mounting surface.	HA-23251
R4	RESISTOR, metal film: precision; 150 ohms ±1%, 1/4 w	H-1510-562
R5	RESISTOR, variable WW: 100 ohms ±10%, 2 w	HA-23871
R6, R7	RESISTOR, variable WW: 10-turn, 100 ohms ±3%, ±.25 linearity	HA-23254
R11	RESISTOR, metal film: precision; 150 ohms ±1%, 1/4 w	H-1510-577
R12, R13	RESISTOR, fixed WW: 200 ohms ±5%, 3-1/4 w	H-1220-31
R14	RESISTOR, fixed comp: 24K ±5%, ½ w	H-1009-631
R15, R55	RESISTOR, variable WW: 500 ohms	HA-11909
R16	RESISTOR, fixed comp: 18K ±10%, ½ w	H-1009-639
R17, R36, R37, R48	RESISTOR, fixed comp: 4.7K ±10%, ½ w	H-1009-350
R18	RESISTOR, fixed comp: 6.8K ±10%, ½ w	H-1009-640
R19	RESISTOR, fixed comp: 1.8K ±10%, ½w	H-1009-446
R20	RESISTOR, fixed comp: 3.3K ±10%, ½ w	H-1009-419
R21, R34, R43, R44, R45	RESISTOR, fixed comp: 2.2K ±10%, ½w	H-1009-434
R22, R26	RESISTOR, fixed comp: 220 ohms ±10%, ½ w	H-1009-544
R23, R56	RESISTOR, fixed comp: 1K ±10%, ½ w	H-1009-429
R24	RESISTOR, fixed, metal film: .51 ohm ±5%, ½ w	H-1510-321
R25, R31, R50	RESISTOR, fixed comp: 100 ohms ±10%, ½ w	H-1009-435

Table of Replaceable Parts

DIAGRAM SYMBOL	NAME OF PART AND DESCRIPTION	RFL PART NO.
R27, R41	RESISTOR, variable WW: 50 ohms	HB-11264
R28, R40	RESISTOR, fixed comp: 39 ohms ±10%, ½ w	HA-13252
R29, R51	RESISTOR, fixed comp: 1.5K ±10%, ½ w	H-1009-418
R30, R38	RESISTOR, fixed comp: 10K ±10%, ½ w	H-1009-391
R32	RESISTOR, fixed comp: 470 ohms ±10%, ½ w	H-1009-617
R33, R42	RESISTOR, fixed comp: 47K ±10%, ½ w	H-1009-442
R39, R47	RESISTOR, fixed comp: 47 ohms ±10%, ½ w	H-1009-496
R46	RESISTOR, fixed comp: 22 K ±10%, ½ w	H-1009-430
R49	RESISTOR, fixed, metal film: 6.81K ±1%, 1/4 w	H-1510-544
R52	RESISTOR, fixed, metal film: 18.2K ±1%, 1/4 w	H-1510-545
R53, R58	RESISTOR, fixed, metal film: 2.21K ±1%, 1/4 w	H-1510-546
R54	RESISTOR, fixed comp: 330 ohms ±10%, ½ w	H-1009-497
R57	RESISTOR, fixed, metal film: 332 ohms ±1%, 1/4 w	H-1510-548
R59	RESISTOR, fixed, metal film: 14.7K ±1%, 1/4 w	H-1510-541
R60	RESISTOR, fixed, metal film: 7.5K ±1%, 1/4 w	H-1510-547
R61	RESISTOR, fixed, carbon film: 2.5K ±1%, 1/4 w	H-1510-207
R62, R67	RESISTOR, fixed, carbon film: .625K ±1%, 1/4 w	H-1510-256
R63, R65	RESISTOR, fixed, carbon film: .2775K ±1%, 1/4 w	H-1510-253
R64	RESISTOR, fixed, carbon film: .833K ±1%, 1/4 w	H-1510-220
R66	RESISTOR, fixed, carbon film: 1.666K ±1%, 1/4 w	H-1510-255
R68, R69	RESISTOR, fixed, carbon film: .2175K ±1%, 1/4 w	H-1510-257
R70	RESISTOR, fixed, carbon film: .1043K ±1%, 1/4 w	H-1510-254
R71	RESISTOR, fixed, metal film: 2.5K ±1%, 1/4 w	H-1510-542
R72	RESISTOR, fixed, carbon film: 3.75K ±1%, 1/4 w	H-1510-221
R73	RESISTOR, fixed, carbon film: 4.50K ±1%, 1/4 w	H-1510-251
R74	RESISTOR, fixed, carbon film: 4.75K ±1%, 1/4 w	H-1510-210
R75	RESISTOR, fixed, carbon film: 24.375K ±1%, 1/4 w	H-1510-211
R76	RESISTOR, fixed, carbon film: 24.75K ±1%, 1/4 w	H-1510-212
R77	RESISTOR, fixed, carbon film: 8.333K ±1%, 1/4 w	H-1510-213
R78	RESISTOR, fixed, carbon film: 199K ±1%, 1/4 w	H-1510-214
R79	RESISTOR, fixed, carbon film: 5.194K ±1%, 1/4 w	H-1510-263
R80	RESISTOR, fixed, carbon film: 400K ±1%, 1/4 w	H-1510-252

Table of Replaceable Parts

DIAGRAM SYMBOL	NAME OF PART AND DESCRIPTION	RFL PART NO.
R81	RESISTOR, fixed, metal film: 21.50 ±1%, 1/4 w	H-1510-543
R83, R84	RESISTOR, variable, comp: 100K ±10%, 2 w, S taper	H-23286
S1	SWITCH, toggle: DPDT, 3 position center off	HA-23250
S2	SWITCH, rotary: 1 deck, 2 poles/deck, 2 position	HB-23252
S3	SWITFH, rotary: 4 deck 1 pole/deck, 12 position	HC-23258
S4	SWITCH, slide: DPDT, 3 amp AC, 1 amp DC	HA-9267
T1	TRANSFORMER, power: 115/230 volts, 50/60 Hz	HA-23287
T2	TRANSFORMER, output: amplifier	HB-23255
W1	LINE CORD	HB-9361

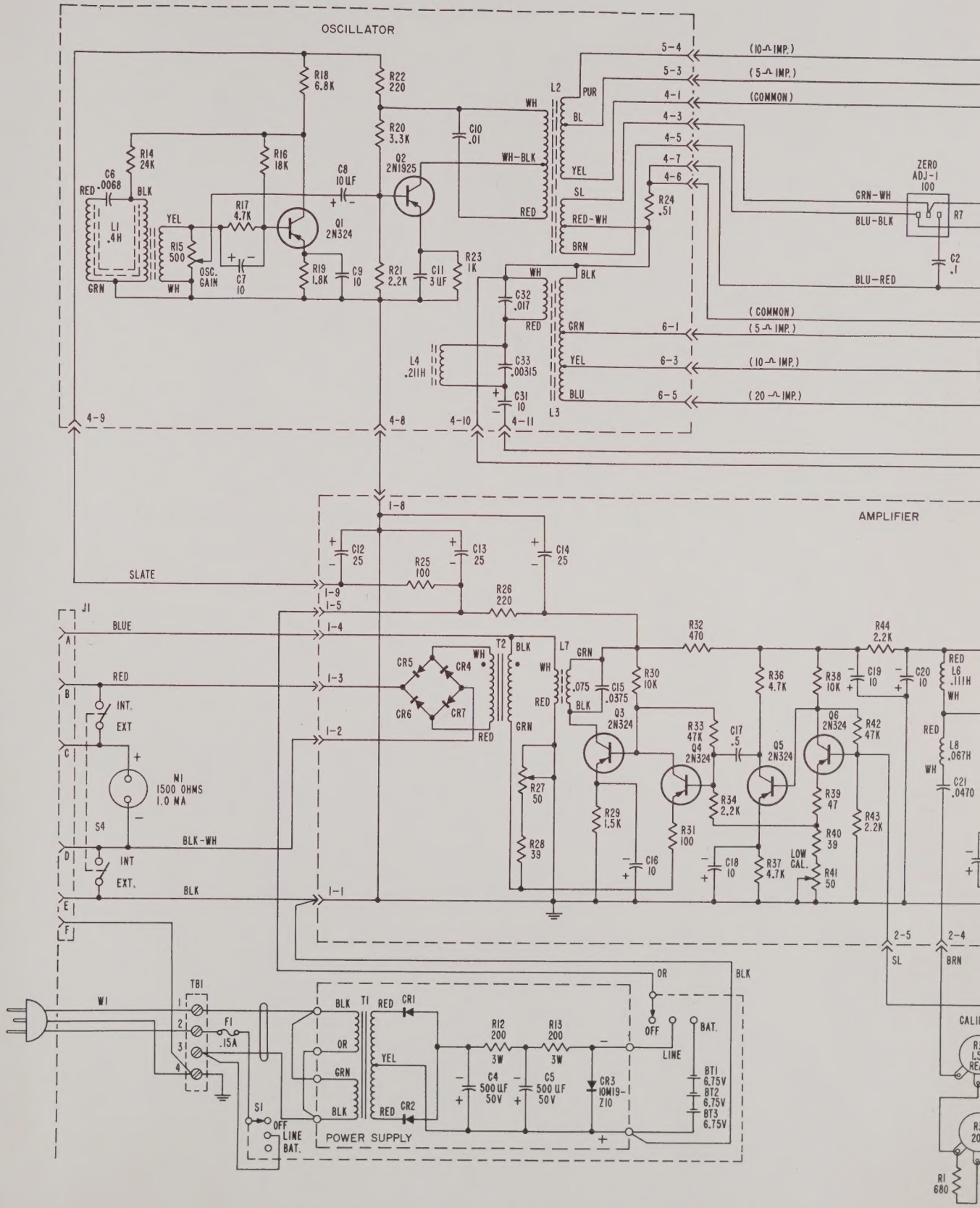
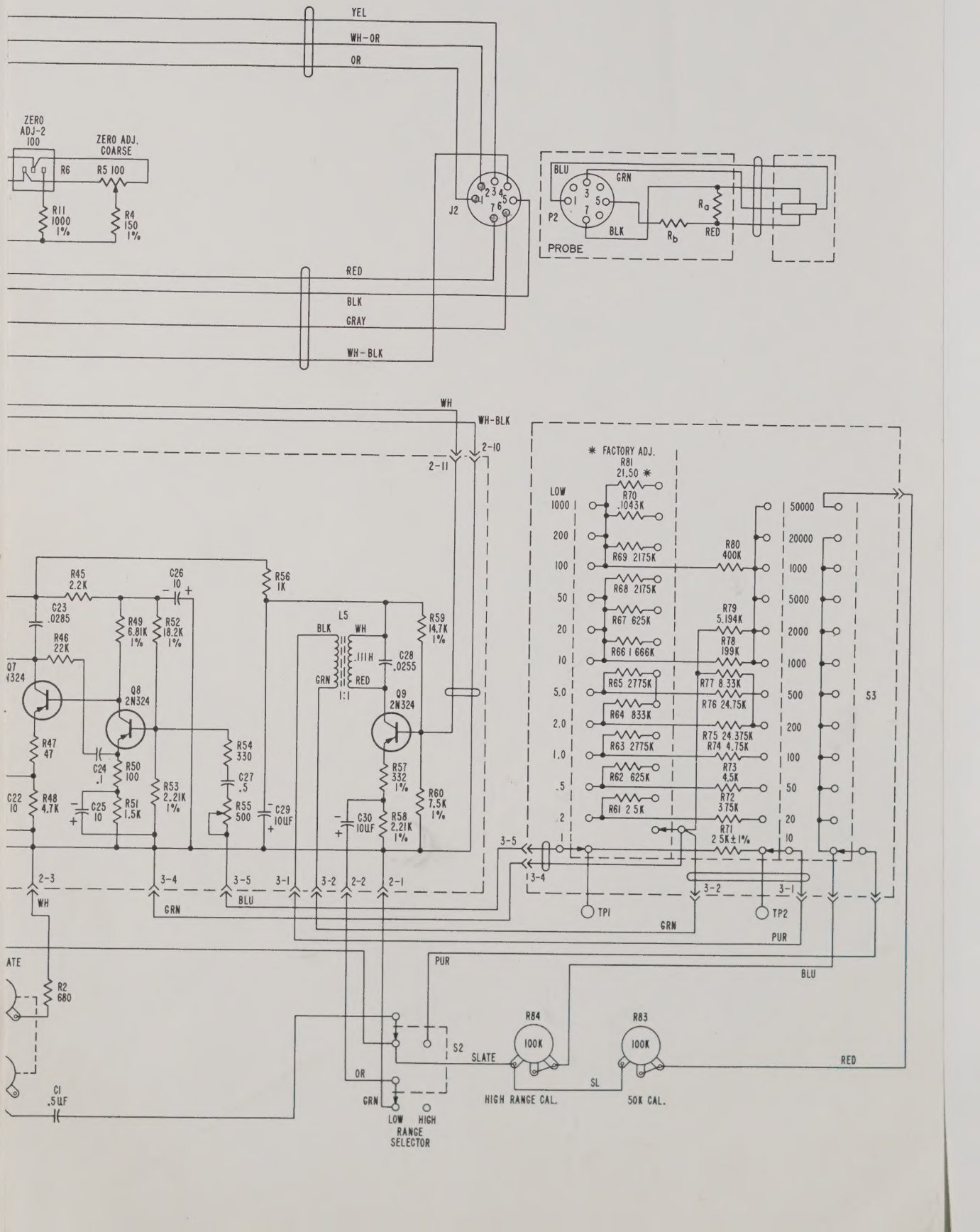
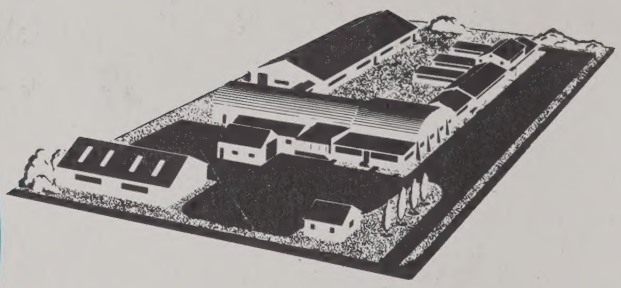


Figure 14. Schematic Wiring Diagram of Model 750 Gaussmeter.


YEL
WH-OR
OR
ZERO ADJ-2 100
ZERO ADJ. COARSE
R6
R5 100
R11 1000 1%
R4 150 1%
J2
BLU
GRN
P2
BLK
RED
PROBE
RED
BLK
GRAY
WH-BLK
WH
WH-BLK
2-10
2-11
* FACTORY ADJ.
R81 21.50 *
LOW
1000
200
100
50
20
10
5.0
2.0
1.0
.5
.2
.1
R70 .1043K
R69 2175K
R68 2175K
R67 625K
R66 1 666K
R65 2775K
R64 833K
R63 2775K
R62 625K
R61 2 5K
R80 400K
R79 5.194K
R78 199K
R77 8.33K
R76 24.75K
R75 24.375K
R74 4.75K
R73 4.5K
R72 3.75K
R71 2.5K±1%
50000
20000
10000
5000
2000
1000
500
200
100
50
20
10
S3
R45 2.2K
C26 10
R56 1K
C23 .0285
R49 6.81K 1%
R52 18.2K 1%
R46 22K
L5
BLK
WH
GRN
RED
.111H
1:1
C28 .0255
R59 14.7K 1%
Q7 2N324
Q8 2N324
Q9 2N324
R47 47
C24 .1
R50 100
R54 330
C27 .5
R55 500
C29 10UF
R57 332 1%
R60 7.5K 1%
C30 10UF
R58 2.21K 1%
C22 10
R48 4.7K
C25 10
R51 1.5K
R53 2.21K 1%
2-3
3-4
3-5
3-1
3-2
2-2
2-1
3-5
3-4
3-2
3-1
TP1
TP2
WH
BLU
GRN
GRN
PUR
PUR
BLU
ATE
R2 680
C1 .5UF
S2
SLATE
OR
GRN
LOW
HIGH
RANGE SELECTOR
R84 100K
R83 100K
HIGH RANGE CAL.
SL
50K CAL.
RED

RFL



Warranty

The Model 750 Gaussmeter carries a warranty of 12 months from date of delivery for replacement of any part, except probes, which fails during normal operation or service. A deficient part should be returned to the factory, shipping charges prepaid, for replacement f. o. b. Boonton, New Jersey.

Radio Frequency Laboratories, Inc.
BOONTON, NEW JERSEY, U.S.A.

Manufacturers of

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